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Chapter 1

# Literature Review

In recent years, scholars have increasingly paid attention to public opinion about environmental issues in the United States (Brulle et al., 2012; Driscoll, 2019; Egan & Mullin, 2017; O’Connor et al., 1999; Shwom et al., 2015), in the European Countries (Lorenzoni & Pidgeon, 2006; Vainio & Paloniemi, 2013) and around the world (Lee et al., 2015; Sun & Han, 2018).

First, some lexical clarifications are reported between global warming versus climate change. Global warming refers to temperatures increase on the Earth's surface (Dunlap, 2014). Instead, climate change refers more generally to changing climatic conditions and their effects (Dunlap, 2014). Public opinion and media use these two terms interchangeably (Weber, 2016). In this study, only the climate change term is used, due to it is more adopted (and more accurate) by the scientific community in the last years (Dunlap, 2014).

“Public opinion on climate change is multidimensional, dynamic, and differentiated. […] It includes, among others, beliefs about anthropogenic climate change, perceptions of climate change risks, concern about its seriousness, and thoughts on what, if anything, should be done to address it” (Shwom et al., 2015, p. 269). Public opinion changes over time and space due to individual, socio-cultural, political, economic, habitat factors (Shwom et al., 2015). We use the term “climate change public opinion” to report attitudes, beliefs, concerns, and worries of people in the environmental field. Besides, a complementary issue of public opinion is behavior. Scholars have found an important relationship between an individual’s “green behaviors”, and therefore all actions to safeguard the environment, and his/her attitudes regarding climate change (Lacasse, 2015; O’Connor et al., 1999; Vainio & Paloniemi, 2013). Lacasse (2015), a professor of Environmental Psychology, suggests that opinion could not be always the reason for the actions performed, but on the contrary attitudes could be used to justify the behavior. Anyway, climate change is a complex, uncertain, and abstract phenomenon, most citizens get information from mass media and they do not experience it directly (Vainio & Paloniemi, 2013). This uncertainty makes opinions even more ambiguous since people have difficulty evaluating the consequences of their actions and solutions or understanding risks. In fact, according to the Special Eurobarometer 91.3 entitled ‘Climate change’, only 20% of citizens in Europe claim that climate change is the single most serious problem facing the world (European Commission, Brussels, 2019). Climate change is considered less important than hunger and poverty in the world.

Whether on one hand, 20% of European perceived the seriousness of the climate change, on the other hand, 80% of them, then, takes some environmental-friendly actions to reduce the phenomenon. Therefore, there is a discrepancy between concern and behavior (Lacroix & Gifford, 2018; Vainio & Paloniemi, 2013). Probably, an individual takes place action only whether he/she knows that he/she can make difference and if he/she knows that also other citizens and governments are moving in the same direction ta safe planet (Lorenzoni & Pidgeon, 2006). Therefore, the relationship between action and attitude also becomes very complex and not obvious.

To sum up, the following chapter is focused on the presentation of the topic of the research: environmental-friendly behavior. Also, we evidence the essential and complicated relationship between pro-environmental behavior and climate change opinion, focusing on climate change risk perception. Lastly, scholars suggest other relevant variables for comprehension of risk perception and behavior in environmentalism, particularly demographic information, such as gender, age, education, and political orientation (O’Connor et al., 1999).

* 1. **Climate Change Risk Perception** 
     1. **The concept of risk perception**

Slovic (1987), a professor of psychology at the University of Oregon, suggests that risk perception varies according to inter and intrapersonal, geographical, cultural, and social influences. In this way, an “objective” risk perception does not exist (Yu et al., 2019). Nevertheless, there are some factors that define perception risk, such as “dread risk” and “unknown risk”: the more a phenomenon is considered unpredictable, uncontrollable, with catastrophic consequences and mostly it is invisible, the more perceived hazard or risk increases (Slovic, 1987). For example, people judge nuclear technology riskier than car accidents, since the first has catastrophic consequences and it is uncontrollable and invisible (Slovic, 1987). According to the professor, perception risk is a mental and social contraction, created in order to help people to tackle uncertainty or danger of the world (Slovic & Weber, 2002). “It does not exist “out there,” independent of our minds and cultures” (Slovic & Weber, 2002, pag. 4).

Risk perceptions are shaped and influenced by different factors, which can be grouped into four categories, suggested in van der Linden’s (2015) Climate Change Risk Perception Model (CCRPM): socio-demographic, cognitive, experiential, and socio-cultural. In the next sections, these categories are explained. The utility of that overview is to comprehend the precursors to climate change risk perception. This variable is fundamental in our study, and therefore it is important to theoretically describe what causes and conditions could be related to individual risk perception.

* + 1. **Socio-demographic dimension**

Socio-demographic factors are related to climate change risk perception, such as gender, education level, age, marital status, city/town size, income, and political orientation.

In literature, females tend to have more concerns than males for a lot of hazards (Finucane et al., 2000) also in environmental issues (Davidson & Haan, 2012; Goldsmith et al., 2013; O’Connor et al., 1999; Zhou et al., 2020). One explanation of the gender gap could be that women are more likely to have “a stronger sense of social responsibility and affinity for taking others’ perspectives” (Goldsmith et al., 2013, pag. 6), and for this reason, they are more concerned than male.

In addition, some studies find that education level is positively correlated with risk perception (Meyer, 2015). The reason why more educated people tend to be more informed on the topic and more aware of the consequences of their actions (Meyer, 2015; Sun & Han, 2018).

Recent studies demonstrated that younger adults are more worried about the consequences of climate change than older (Echavarren et al., 2019; Sun & Han, 2018; Weber, 2016). However, the reasons for this divergence could be two: the *aging effect* and the *cohort* *effect*, which are the result of being at a certain age point or belonging to a particular generation (Torgler & García-Valiñas, 2007). This last option could explain the difference in attitudes between two different generations due to generational variations in socialization and lifestyle (Torgler & García-Valiñas, 2007). In fact, scholars have started to alert and mobilize citizens about climate change in the last few decades.

Regarding marital status, literature suggests that it may influence environmentalism, especially married individual and/or with children are more worried about climate change, since they think at children’s future than single (Torgler & García-Valiñas, 2007).

Additionally, the relationship between the place where individual lives and risk perception is not clear. On one side, citizens who are located in rural should be more in contact with nature and therefore they should have more environmentally values, on the other side, who lives in a city are more active in the environmental policies (Torgler & García-Valiñas, 2007).

The economic situation is also correlated with environmental attitudes and therefore with risk perception. In general, wealthier people expect a clean and healthy planet (Torgler & García-Valiñas, 2007).

Lastly, political ideology. American literature suggests that Democrats and Liberals are more likely to believe and to concern about climate change than Republicans and Conservatives (Davidson & Haan, 2012; Egan & Mullin, 2017; Fielding et al., 2012; Liu et al., 2014; McCright, 2011). Additionally, McCright, Dunlap, and Marquart-Pyatt (2016), some of the most important sociologists in the field of Environmental Sociology, extend these findings also in the European Union. However, in Europe, the distinction between Democrats (left) and Republicans (right) is not clear and uniform. In Western Europe, the left is related to change and equality, instead of in former Communist countries, this identification cannot be found (McCright et al., 2016). In fact, they extend the same findings, thus a polarization of climate change, in only Western countries: citizens on the right are unlikely to recognize the phenomenon as a serious issue than those on the left (McCright et al., 2016). Even though “the effect of left–right ideology in Western Europe is considerably weaker than the effect of political ideology (and party identification) in the USA” (McCright et al., 2016, pag. 13). Instead, citizens of Eastern Europe are not divided from an ideological points of view on that topic, due to the irrelevance of political issues and then the difference ideologization and identification of left-right (McCright et al., 2016).

To summarize briefly more educated and liberal young women are more likely to show higher level of risk perception than older and conservative men (Xie et al., 2019).

* + 1. **Cognitive dimension**

Knowledge is the main factor in the cognitive dimension related to climate change risk perception(Bradley et al., 2020; Hidalgo & Pisano, 2010; O’Connor et al., 1999). Van der Liden (2015), Professor of Social Psychology at the University of Cambridge, suggests that the knowledge about the causes or impact of climate change can lead to improving individuals’ concern. However, the professor empathizes that we cannot make this important distinction “between an individual's “subjective” knowledge (i.e., what people think is true) and the actual “evidence” (insofar a clear scientific consensus exists, e.g., that burning fossil fuels contributes to climate change) (van der Linden, 2015, pag. 114). However, people with accurate knowledge of the phenomenon seem to perceive it as a serious problem and, at the same time, they want to fight it (Bradley et al., 2020; Hidalgo & Pisano, 2010).

* + 1. **Experiential dimension**

This section is pointed to the importance of emotions or effects and of personal experiences with natural disasters in risk perception.

Firstly, emotion. “Risk as feeling” refers to instinctive (with or without consciousness) reaction to danger: people immediately judge a potential problem as positive or negative feelings (Slovic & Peters, 2006). More the immediate feeling is negative, more risk perception increase. When an individual becomes to use this feeling as the first influencer of behavior, it means that emotion is called “the affect heuristic” (Slovic & Peters, 2006). Some researchers evidence that affects is a predictor of climate change risk perception, and therefore negative feelings improve concern (van der Linden, 2015). On the contrary Taylor et colleagues (2014) affirm that extreme negative emotions can create the opposite effect: fear and anxiety can lead to greater psychological distance and apathy towards climate change.

Secondly, personal experiences with a hazard or extreme weather events, such as extraordinarily hot or cold weather, storms, and flooding, forest fires, patterns of precipitation. However, also directly experiences in climate change are not possible, but all information is influenced by mass media (van der Linden, 2015). Not all citizens have experienced these situations personally. However, familiarity with extraordinary weather events makes risk more concrete and real, increasing concern and decreasing psychologically the distance from danger (Akerlof et al., 2013; Bradley et al., 2020; Taylor et al., 2014; van der Linden, 2015).

* + 1. **Socio-cultural dimension**

One of the most important approaches to risk perception is the cultural theory defined by Mary Douglas in the 1960s. According to theory, risks are a social construction and they depends on: “(a) the form of social relationships people maintain; (b) cultural biases such as shared values ​​and beliefs including views on human nature, views on society, risk perceptions, and so-called myths of nature, which especially refer to biases toward environmental risks; and (c) preferred behavioral strategies” (Steg & Sievers, 2000, pag. 251). Cultural theory suggests that people can be divided into four groups based on their worldview and values: fatalists, hierarchists, individualists, and egalitarians, based on their attitudes and perception (Steg & Sievers, 2000). Fatalists perceive the reality as the product of chance and it is out of human control, hierarchists appreciate hierarchies and institutional values and for them, nature can be safeguarded by regulations; individualists focus attention on personal freedom and they see nature as benign, lastly egalitarians emphasize group welfare but, at the same time, the hierarchy (it means inequality) and for them nature is fragile (Taylor et al., 2014; Wildavsky & Dake, 1990).

Various studies have found a significant relationship between “cultural worldview” and climate change attitudes (Steg & Sievers, 2000; Taylor et al., 2014). For example, the values of egalitarians are positively correlated with environmentalism, while those of individualists are negatively correlated (Steg & Sievers, 2000).

* 1. **Pro-environmental Behaviour**

“Pro-environmental behaviour is most commonly defined as ‘intentionally reducing the negative impact that an action can have on the environment” (Dono et al., 2010, pag. 178). Generally, scientists mean pro-environmental behaviour like walking, recycling, energy saving. It is an intent-oriented definition, which is different from impact-oriented one: the first highlights the action as such, it may not produce an environmental impact, the second must necessarily have an sustainable effect (Stern, 2000). When scholars focuses on individual’s attitudes to understand behaviour, as in this case, they adopt an intent-oriented definition (Stern, 2000).

* + 1. **Types of Environmentally behaviour**

According to Stern (2000), president and senior scholar of Social and Environmental Research Institute, there are four different types of environmental behaviour: environmental activism, nonactivist behaviours in the public sphere, private-sphere environmentalism, other environmentally significant behaviours.

Environmental activism concern the active involvement of citizens in manifestation and organizations (Dono et al., 2010; Stern, 2000).

Nonactivist behaviours in the public sphereconcern individuals who support for public policies or environmental citizenship, their actions have a positive, but indirect, impact on environment (Stern, 2000).

Private-sphere environmentalismrefers simply to green consumer (Stern, 2000).

Lastly, other environmentally significant behaviours refer to individuals who have a positive impact on environment even if though other behaviours, such as an worker can influence pro-environmental action of organization to which he/she belongs (Stern, 2000).

* + 1. **Factors influencing PEB**

Sociologists suggest that pro-environmental behaviour is not only motivated by environmental attitudes (Stern, 2000). There are also psychological, social and economic factors that can influence and mitigate behaviour (Whitmarsh & O’Neill, 2010). We can organize these factors into three main group: internal, external factors and, again, socio-demographic.

***Internal Factors***

Internal factors are motivation, environmental knowledge, attitudes, emotion (Kollmuss & Agyeman, 2002). One of the most important theories which aims to predict behaviour is: Theory of Planned Behaviour (TPB). It affirms that a behaviour is determined by: attitudes towards that action, subjective norms and perceived behavioural control (Oreg & Katz-Gerro, 2006; Whitmarsh & O’Neill, 2010). Therefore, actual behaviour is determined by behavioural intention, which has its turn is influenced by both attitudes and social, or normative, pressures (Kollmuss & Agyeman, 2002).

Generally, as just showed with the theory, motivation, values, knowledge are interconnected and mixed with each other. Motivation (unconscious or conscious) drives action and it could be shaped and linked also by environmental knowledge and awareness (Kollmuss & Agyeman, 2002). Also values, influenced by social network (family, peer-groups, education), shape motivation and then behaviour. “The more strongly individuals subscribe to values beyond their immediate own interests, that is, self-transcendent, prosocial, altruistic or biospheric values, the more likely they are to engage in pro-environmental behaviour” (Steg & Vlek, 2009, pag. 311). Finally, emotions. Emotional involvement are shaped by knowledge about the topic, since as we have already shown, climate change is an abstract and complex problem (Kollmuss & Agyeman, 2002). However, some individuals experience directly of climate change (extreme atmospheric phenomena) and then they feel fear, anger, guilt (Kollmuss & Agyeman, 2002). These negative feelings can lead to refuse to accept reality, rational distancing from problem, apathy, and delegation personal responsibility (Kollmuss & Agyeman, 2002). Therefore, whether the emotion is too strong and extreme, it can lead to prevent and block behaviour.

We can summarize that mainly attitudes and values have a powerful influence, also if indirectly, on behaviour.

***External Factors***

It is also important to take into account context where individuals are embedded. According to Kollmuss & Agyeman (2002), institutional, economic, and socio-cultural factors influence individuals’ behaviour. Firstly, “many pro-environmental behaviours can only take place if the necessary infrastructure is provided (e.g. recycling, taking public transportation)” (Kollmuss & Agyeman, 2002, pag. 248). It is obviously that if there is no public transport, an individual can not take place an environmental-friendly action. Then, economic factors are essential in the decision-making process. People could be partially influenced by economic incentives to behave pro-environmentally, and therefore vice-versa for expensive ones and lack of pro-environmental action. Lastly, cultural norms and cross-cultural differences play a very important role in shaping people’s behaviour (Kollmuss & Agyeman, 2002; Oreg & Katz-Gerro, 2006). Socially accepted behavior vary by country and culture and can influence behavioural pattern at individual level.

***Socio-demographic factors***

According to Larson and colleges (2011), the effect of socio-demographic characteristics on PEB has not been adequately explored, as opposed to the relationship on attitudes, as widely discussed above with perception risk. Traditionally, poor, and uneducated citizens show lower PEB than rich and highly educated ones (Larson et al., 2011). Women, being more concerned, are more likely to behave sustainably (Larson et al., 2011; Vicente-Molina et al., 2018). As we have already explained, this gap could be due to gender socialization theory: women should be more cooperative, empathic, and protective (in this case towards nature) than men (Vicente-Molina et al., 2018). Therefore, similar to risk perception, green consumers, or more in general environmentally activists, are “young, female, well educated, liberal and wealthy” (Gilg et al., 2005, pag. 484).

### **Self-reported Behaviour / measurement of behaviour**

In social research a common measurement of PEB is based on respondents’ self-reports through questionnaire items (Steg & Vlek, 2009). Self-reported data reports what individuals believe they have done, and it is in contrast with behavioural data (Veltri, 2019). A problem arises due to individuals may not give an accurate answer of their real behaviour (Gatersleben et al., 2002). “Self-reported behavior reflects perceptions or beliefs about people’s own behavior rather than their actual behavior. Factors such as social desirability and other types of (conscious or unconscious) response bias may result in inaccurate reports of actual behavior” (Gatersleben et al., 2002, pag. 337). Therefore, when interviewer asks about behaviour, it is probably that interviewed reports his/her intention rather than his/her actual behaviour (Chao & Lam, 2011). Social responsibility and social desirability can lead to provide an inaccurate information of behaviour (Chao & Lam, 2011; Veltri, 2019). Whether on one side the amount of individuals’ pro-environmental behaviour could be overestimated and not entirely precise, on the other side dichotomized questions about serf-reported behaviours (“I do” or “I don’t”) result more accurate and reliable (Kaiser et al., 2003).

* 1. **From Climate Risk Perception to Pro-environmental Behaviour**

In the previous sections we described two main concepts of research: climate change risk perception and pro-environmental behaviour. These two concepts are completely separated with each other. One does not automatically involve the other. In fact, literature is not clear about their relationship. Some research demonstrates the importance of climate change risk perception to predict pro-environmental behaviour (Xie et al., 2019; Yu et al., 2019; Zhou et al., 2020).Greater risk perception is positively correlated with pro-environmental action, becoming the main predictor and intermediary on behavioural (Xie et al., 2019). When people became aware and then concerned about the issue, they are more likely to behave eco-sustainably in order to mitigate environmental problem (Zhou et al., 2020). Instead, according to Stern (2000) and O’Connor and colleagues (1999) suggest that risk perception may fail to lead to pro-environmental behaviours. Two individuals who have the same level of concern may react by having completely divergent behaviour (Zeng et al., 2020). The reason is that there are other factors that influence the decision-making process. Eco-friendly behaviour may be motived simply by financial interests and not by a high risk perception (Stern, 2000). Otherwise, as we have seen in the paragraph above, high risk perception may lead to apathy or to reject reality and therefore no pro-environmental actions are implemented (Kollmuss & Agyeman, 2002). This discrepancy is called as the value-action gap (Lacroix & Gifford, 2018).



Figure 1: A schematic overview of Protection Motivation Theory (explained by Bubeck et al., 2018)

An explanation for this value-action gap is provided by the protection motivation theory (PMT), explained by Bubeck end colleagues (2018). It has become popular in order to explain “the risk-reducing behavior of residents against natural hazards” (Bubeck et al., 2018, pag. 1239). According to the theory, the decision of pro-environmental behavior or not is driven by two different cognitive processes: threat appraisal (or referred as “risk perception”) and coping appraisal (Bubeck et al., 2018). When a threshold of risk perception (threat appraisal) is exceeded, individual begins to adopt possible measure to reduce the threat, which is referred as coping appraisal (Bubeck et al., 2018). This latter includes three factors: “the perceived effectiveness of a certain measure (response efficacy), the perceived ability to implement the respective measure (self-efficacy), and the perceived costs associated with its implementation (response cost)” (Bubeck et al., 2018, pag. 1240). The interaction between risk perception and coping appraisal affects behaviour. If an individual has high concern and high coping appraisal then he/she will have pro-environmental behavior, otherwise if he/she has high risk perception but low coping appraisal then he/she will nonprotective response (Bubeck et al., 2018). However, nowadays there is the revised theory introduced by Rogers, who adds some variables that influence risk perception and coping appraisal: environmental and intrapersonal sources (Bubeck et al., 2018). Prior experiences, socio-demographic characteristics, personal attitudes, contextual factors may influence and modify these two dimensions, which in turn affect the behavioural response.

Chapter 2

# Data and Method

## **2.1 Research Questions**

The first chapter explores the main theoretical aspects that are related to attitudes towards climate change. Many elements are presented: climate change risk perception, pro-environmental behaviour and their respective factors that influence them. All these concepts are interconnected with each other. Thus, firstly it is important to understand the aim of the research. In order to perform a quantitative analysis of pro-environmental behaviour in European countries, the study is focused only on, partially, protection motivation theory. The research is interested in predicting exclusively pro-environmental behavior, and not climate risk perception. As we have seen in the literate review, external and internal conditions, such as socio-demographic characteristics, beliefs, and concerns about climate change, can lead to encourage eco-friendly behavior. We said that the research is based partially on protection motivation theory since the concept of coping appraisal is not considered as predictors, due to the lack of appropriate data. Additionally, the fist aim of the study is to understand the main factors and predictors that influence directly pro-environmental behaviour. The intermediary role of risk perception is not studied. Therefore, all the variables, which influence behaviour (directly or indirectly), of PMT are considered. Another important point to highlight in that there is no distinction among different types of pro-environmental behaviours.

According to the existing literature, it is assumed that:

Hp1: higher individual climate change risk perception will positively influence and predict pro-environmental behaviour;

Hp2: citizens’ positive attitudes towards climate change will positively influence their pro-environmental behaviour;

Hp3: Demographic characteristics have an effect on pro-environmental behaviour, in particular:

1. Higher education has a positive effect on pro-environmental behaviour;
2. Women are more likely to have pro-environmental behaviour;
3. Higher income has a positive effect on pro-environmental behaviour;
4. Younger are more likely to have pro-environmental behaviour;
5. Liberal are more likely to have pro-environmental behaviour.

In the second part of the analysis, we want to understand the main factors to predict behaviour, but according to the different level of individual’s risk perception. In fact, the illustrated literature shows especially the importance of risk perception in predicting action. However, no study has tried to understand what variables influence and vary behaviour whether level of risk perception changes. The relevance of study is to cover the existing gap.

It is assumed that:

Hp4: citizens’ green attitudes who have a high climate change risk perception will positively influence their pro-environmental behaviour;

Hp5: citizens’ non-green attitudes who have a low climate change risk perception will negatively influence their pro-environmental behaviour;

## **2.2 Methodology**

The research, as already explained, is mainly composed of two different parts: the first, that uses unsupervised learning to obtain profiles of citizens, and the second, that uses supervised learning to predict pro-environment behaviour.

The first set of methods focuses on identifying some profiles of citizens using different types of unsupervised learning techniques: Partition around medoids (PAM) clustering and Correlational Class Analysis (CCA). Unsupervised learning techniques look for patterns without any knowledge of the classification purpose.

PAM is a type of clustering used mainly for categorical features (Shendre, 2020). It seeks to identify a finite set of clusters or subgroups to describe data (Fonseca, 2013; James et al., 2013). This method creates some subgroups in order to maximize both the similarity within clusters and the differences among other groups. Clustering needs to obtain profiles of citizens toward climate change.

Correlational Class Analysis (CCA) identify such “cultural schemas” in a survey data, in particular in a public opinion data (Boutyline, 2017; Rossoni et al., 2020). This technique is an implementation of Relational Class Analysis (RCA) developed by Goldberg (2011) and it “seeks to parse out groups, or classes, of like-minded individuals. Unlike these methods, however, it uses relationality to compare these individuals not on their attitudes per se but on the patterns of relations between their attitudes” (pag.1399). Therefore, the goal of RCA is to partition individuals into groups which shared “cultural classes” (Rossoni et al., 2020).The shared “cultural schemas” “does not imply having identical attitudes or behaviours, rather it suggests being in agreement on the structures of relevance and opposition that make actions and symbols meaningful” (Goldberg, 2011, pag. 1402). Therefore, it tries to find patters of associations between attitudes or behaviours in terms of “relationality”. In addition, it tries to find relationships both between individuals and between variables, combining clustering analysis and multidimensional scaling or factor analysis (Goldberg, 2011). The difference between RCA and CCA lies in the concept of “relationality”. In fact, while Goldberg (2011) uses linear dependency between two individuals vectors of responses in order to find the shared cultural schemas, CCA suggests to adopt Pearson’s correlation (Boutyline, 2017). Boutyline (2017) demonstrated that CCA produces more accurate results. In this case, there is no relationship between cases as in clustering, rather than between variables.

Only categorical ordinal variables are used with these two algorithms, in fact only climate change questions are considered, except for the dependent variable, pro-environmental behaviour, and climate change risk perception.[[1]](#footnote-1) In fact, five questions are selected to fit these methods. The questions proposed are on the type of governance on climate change. The responses were on 4-point Likert scale, with the following gradations and labels (the latter change according to the questions):

1 = Totally agree/ Very important

2 = Tend to agree/ Fairly important

3 = Tend to disagree/ Not very important

4 = Totally disagree/ Not at all important

The purpose of this part of analysis is to find some different types of citizens, called clusters or classes, that better describe the data used. In fact, through these techniques some new segmentations of citizens could be identified and then they could help to find new explanations to the phenomenon studied. Theoretically, using these two different types of segmentations of citizens, the results should be opposite. On the one side, the traditional clustering profiles the data according to similar attitudes, therefore we will find different types of *green identity*. On the other side, CCA finds shared cultural schemas, structure of thought. Eventually, the classes obtained from PAM clustering and correlational class analysis are used as predictors in the subsequent classifications.

The second set of methods focuses on prediction climate change pro-environment using different types of supervised learning techniques and classifiers. In fact, classification is used when a categorical variable is predicted (James et al., 2013). “The methods used for classification first predict the probability of each of the categories of a qualitative variable” (James et al., 2013, p. 127).

The different techniques of classifiers are briefly presented as follow.

The pro-environmental behaviour prediction starts with a Logistic Regression. It is a form of binary regression and it explains relationships between a categorical outcome and some continuous or discrete predictors (Peng et al., 2002). It models the probability of being to a particular category (Peng et al., 2002; Stoltzfus, 2011).

The model requires some assumptions:

1. independence of errors;
2. linearity in the logit for continuous independent variables;
3. the absence of multicollinearity among explanatory

variables;

1. the absence of extreme outliers

(Stoltzfus, 2011)

However, some assumptions are violated. In fact, there is no present linearity in the logit for age variable. In addition, some outliers are found in climate change risk perception, but they are not so far away from the rest of the value.

In spite of the robustness of the logistic regression models, data cannot fully satisfy the assumptions, also decision tree models are fitted. Decision Tree is a “flow-chart-like hierarchical tree structure” (Jenhani et al., 2008, p. 786) and it is composed of three elements: nodes, edges and leaves. Nodes represent attributes or variables, edges correspond to the different possible attribute values and lastly leaves include objects that typically belong to the same class or that are very similar (Jenhani et al., 2008). The main advantages of decision tree are that it has not assumptions and especially it produces graphical representation, which make it easier to read and to interpret the model.

The analysis continues with another robust model: Random Forest, which is produces of multiple and randomized decision trees that operate as an ensemble (Belgiu, 2016; Biau & Scornet, 2016). This classifier “can successfully handle high data dimensionality and multicollinearity, being both fast and insensitive to overfitting” (Belgiu, 2016, p.24). Another advantage is that it can dealing with unbalanced data, as in this case (Belgiu, 2016).

The last classifier used is Gradient Boosting. It is similar to random forest algorithm, but this case each new tree is been created using the previous ones, in order to correct mistakes made (James et al., 2013). Instead of fitting a large amount of trees separately, it learns slowly by previous trees recursively.

The last two tree-based methods, producing multiple trees, have become more popular since they improve in prediction accuracy but they loss in interpretation (Belgiu, 2016; James et al., 2013).

To sum up, all these classifiers have the possibility to predict pro-environmental behaviour. In the figure 1, you can see the distribution, unbalanced, of the observations according to the dependent variable. We have 14327 individuals who declared to have taken any action to fight climate change over the past six months and 7651 who have not.

Figure 2: Pro-environmental behavior distribution

Socio-demographic variables, classes created form k-means and CCA and climate change risk perception are used as predictors. In fact, we want also to investigate the main factors and predictors that influence pro-environmental behavior. This process is achieved thanks to selected models, logistic regression and tree-based methods, which can determine the importance of independent variables. This part is considered quite conventional according to the literature review, above-mentioned: variables selected have already been used previously, even if have mostly used more traditional techniques (and not machine learning techniques). Instead, the originality of this research can be found in next step.

Due to the theoretical relevance of climate change risk perception, in the pro-environmental behaviour’s prediction, two different analysis, according to the degree of this main explanatory variable, are performed. Two datasets are created: one with only the observations of individuals who declared very worried about the phenomenon (responses with a score greater than or equal to 6 are considered), and one with those who do not care (score less than or equal to 5). The same algorithms, just described, are fitted for the two different subsets. The aim is to discover the divergent variables that predict actions and whether there are relevant differences between those who care and those who do not care.



Figure 3: Pro-environmental behavior distribution according to Climate Change Risk Perception

The figure 2 indicates the distribution of our dependent variable according to the 2 created subsets. The subset with the observations of those who warried is definitely greater: 12988 observations of those who have not done any ecological behaviour and 6084 individuals who have done nothing. Instead, the second dataset is composed by the observations those who do not care about environment. We have few cases, but they are balanced: 1339 and 1567, respectively who does environmentally behaviours and who does not.

## **2.3 Data Description**

As aforementioned, the research studies pro-environmental behaviour of European citizens. The main data used in this project come from one wave of Eurobarometer survey. The Eurobarometer is a public opinion research institution in the European Union with the aim to examine a variety of topics and attitudes. The European Commission conducts Standard & Special Eurobarometer periodically. We used the Special Eurobarometer 91.3 dataset, entitled “Climate Change”, made available by the Eurobarometer Open Data website. This survey is collected in April 2019 using face-to-face interviews. There are 27655 respondents from 28 countries of the European Union. The Eurobarometer data are publicly available from GESIS (European Commission, Brussels, 2019). Eurobarometer 91.3 asks some questions about environmental issues and some socio-demographic information. Some relevant items about climate change and socio-demographic variables are selected.[[2]](#footnote-2)

### **2.3.1 Data Cleaning**

The first step before performing the analysis is data cleaning. In order to obtain an accurate analysis some observations are dropped. In fact, missing data or refusal answers of climate change issues are not considered in the final dataset. The missing data of our dependent variables, pro-environmental behavior (encoded as qb5), is dropped since the analysis is based on the predictions of a dichotomous outcomes (coded as 1 = Yes, 0= No). Even if this is a self-reported behaviour, it is considered valid and accurate according to the literature, being a dichotomous variable. Climate change risk perception (qb2) is measured on 1-10 scale, and no answers are dropped to keep the variables as a metric, as some previous research had done (Echavarren et al., 2019). The question does not directly about the perceived risk but it is referred of *seriousness* of the phenomenon in the present moment and it is a one-dimension of climate change risk perception (Echavarren et al., 2019). Successively, other questions regarding the topic are selected, all expressed on a 4-point Likert scale, as already mentioned above. Also, in this case, missing or refusal data is removed. The reason why PAM clustering and CCA does not accept missing data and therefore the entire observation must be removed. Instead, socio-demographic variables are for the most part categorical and therefore *refusal* or *dk* (don’t know) are kept among the answer choices. However, some transformations are adopted in these variables. Political orientation (d1) is originally presented in a 10-points Likert scale (1 = left to 10 =right). It is transformed into a categorical variable: the answers 1-2 are become “left”, 3-4 “centre-left”, 5-6 “centre”, 7-8 “centre-right”, 9-10 “right” and *dk* or *refusal* “not positionable”. For the current situation variable (d7), some new categories are created depending on whether individual has declared that he/she lives with “partner”, “partner and children” or he/she is “single” or “single (and he/she lives) with children”. The education variable (d8), or rather when he/she finished studying, is been converted from continuous to categorical. According to scholars (Abu-Omar & Rütten, 2008; Loyen, 2016) five categories are created: “up to 15 years”, “16-19 years”, “20+years”, “still studying” and “refusal/other”. Gender (d10) and age (d11) are not manipulated since nobody answered with “other” and therefore the first variable is a dichotomous “male” and “female” option, while the second one is maintained as continuous. For place of residence (d25) and class identity (d63) variables, the categories proposed by the Eurobarometer are kept. Respectively, the first has the following classes: “rural area or village”, “small or middle sized town”, “large town” and “dk” (don’t know). While the second one has the options: “the working class of society”, “the lower middle class of society”, “the middle class of society”, “the upper middle class of society”, “the higher class of society”.[[3]](#footnote-3)

Lastly, country variable is considered. Eurobarometer surveys collected about 1000 interviews on the average for each country, except for small nations, such as Malta and Luxembourg. Only a manipulation is computed: West and East Germany are combined into one country “Germany”.

To sum up, the final dataset has 21978 respondents (out of 27655).[[4]](#footnote-4)

**Analysis**

The following section illustrates the different steps undertaken to obtain a prediction model for pro-environmental action. In particular, the first step consists of Exploratory Data Analysis, in order to investigate climate change attitudes. Then, the best fitting models tested to predict the final price are presented.

**Exploratory Data Analysis**

Climate change attitudes do not vary only between countries but also between citizens in the same country (Xie et al., 2019). As you can see in the figure 1, the percentage of those who believe that climate change is the single most serious problem varies significantly according to country. For example, Bulgaria and Croatia obtain the smaller percentage, that is 11% of citizens who think climate change is the single most serious problem. On the contrary, about 1 out 2 Sweden’s citizen indicated climate change.



Figure 4: Single Most Serious Problem

Another interesting example is the difference in the climate change risk perception. As you can see in the figure 2, about half of citizens of Malta and Luxemburg declared that they are extremely worrying about the phenomenon studied.



Figure 5: Climate Change Risk Perception

Attitudes among countries could be so vary since they are influenced by different contextual factors (Echavarren et al., 2019; Krajhanzl, 2010). According to Echavarren and colleagues (2019), opinion, perception and behavior could change due to different natural hazards and political context. For example water deficit or temperature growth regarding natural hazards and the “level of environmentalism in the political arena of a given country” (Echavarren et al., 2019, p. 815) for political variables. These macro-variables should be significant mediators in explaining risk perception or pro-environmental behaviour. Some indexes are considered with the sole purpose of remembering that they could affect and moderate the phenomenon studied. Then, they are not inserted in the final models since only multilevel method could be adopted. In addition, the aim of the research is not to evidence national or cultural differences, but on the contrary, it is to find patterns at individual levels, regardless of the place of origin. However, these differences at the macro levels are presented.

For the natural hazards the 2020 Environmental Performance Index (EPI) is used (the 2019 EPI is not available in order to use the same data of year of the survey) (Yale Center for Environmental Law & Policy, 2020). EPI quantifies numerically environmental health and ecosystem vitality around the world. Some indicators that composed the index are: air pollution, drinking water quality, species protection. These phenomena could be positively affect climate change concerns and opinion (Echavarren et al., 2019). In fact, citizens should perceive biodiversity loss or temperature increases, leading to greater apprehension. The figure 3 shows the score across European Union (EU). The best score is obtained from Denmark, while the worst from Bulgaria.

Figure 6: The 2020 EPI

For the political context the 2019 Climate Change Policy Performance is selected, which is a mesarument of national and international climate policies (Burck, 2018) developed by organisation Germanwatch. It is one of the indicators that belongs to the Climate Change Performance Index (CCPI). The indicator constitutes the measurements taken by governments in order to reduce current level of GHG emissions per capita or the use of renewavle energy. Briefly it is defined as a measure of countries’ progress and their capacity to climate protection (Burck, 2018). In the Climate Change Policy the record goes to Portugal and Bulgaria gets the lowest score in all European Union, as the figure 4 shows.

According to scholars (Echavarren et al., 2019; van der Linden, 2015) socio-cultural context influces individual attitudes towards climate change concerns. Therefore, the notable diferencess in attitudes across coutries should be also due to these indicators. In fact, “sociological research suggests that contextual factors and processes can be powerful forces shaping how individuals and communities engage with the issue” (Lee et al., 2015, p. 1014). There are different ecological tax reforms or cultural habits that affect and shape individual climate change attitudes and behavior.

Figure 7:The 2019 Climate Change Policy

In this way, It is important to remember that these macro-factors should have an effect also in individual preferences.

**APPENDIX**

**APPENDIX A. Survey Question Wording and Coding**

|  |  |  |
| --- | --- | --- |
| **Variables** | **Questions** | **Coding** |
|  | ***Question about Climate Change issues*** |  |
| qb2 | And how serious a problem do you think climate change is at this moment? Please use a scale from 1 to 10, with '1' meaning it is "not at all a serious problem" and '10' meaning it is "an extremely serious problem" | 1-10 scale: 1= Not at all a serious problem to 10= An extremely serious problem |
| qb4\_3 | To what extent do you agree or disagree with each of the following statements? Taking action on climate change will lead to innovation that will make EU companies more competitive | 1-4 scale: 1= Totally agree to 4 = Totally disagree |
| qb4\_5 | To what extent do you agree or disagree with each of the following statements? Adapting to the adverse impacts of climate change can have positive outcomes for citizens in the EU | 1-4 scale: 1= Totally agree to 4 = Totally disagree |
| qb5 | Have you personally taken any action to fight climate change over the past six months? | 1= Yes; 0= No |
| qb7 | How important do you think it is that the (NATIONALITY) government sets ambitious targets to increase the amount of renewable energy used, such as wind or solar power, by 2030? | 1-4 scale: 1= Very important to 4= Not at all important |
| qb8 | How important do you think it is that the (NATIONALITY) government provides support for improving energy efficiency by 2030 (e.g. by encouraging people to insulate their home or buy electric cars)? | 1-4 scale: 1= Very important to 4= Not at all important |
| qb9 | To what extent do you agree or disagree with the following statement: We should reduce greenhouse gas emissions to a minimum while offsetting the remaining emissions, for instance by increasing forested areas, to make the EU economy climate neutral by 2050. | 1-4 scale: 1= Very important to 4= Not at all important |
|  | ***Socio-demographic information*** |  |
| d1 | In political matters people talk of "the left" and "the right". How would you place your views on this scale? | 1-10 scale: 1= left to 10= Right |
| d7 | Which of the following best corresponds to your own current situation? | Categorical |
| d8 | How old were you when you stopped full-time education? | Number in actual years |
| d10 | Gender | Female; Male |
| d11 | How old are you? | Number in actual years |
| d25 | Would you say you live in a...? | Categorical |
| d63 | Do you see yourself and your household belonging to…? | Categorical |
| country | Country | Categorical |

**APPENDIX B. Summary Statistics.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variables** | **Obs.** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| **Qb5** | 21978 |  |  |  |  |
| *Yes* | *14327* |  |  |  |  |
| *No* | *7651* |  |  |  |  |
| **Qb2** | 21978 | 7.93 | 2.02 | 1 | 10 |
| **Qb4\_3** | 21978 | 1.74 | 0.71 | 1 | 4 |
| **Qb4\_5** | 21978 | 1.90 | 0.87 | 1 | 4 |
| **Qb7** | 21978 | 1.52 | 0.65 | 1 | 4 |
| **Qb8** | 21978 | 1.56 | 0.68 | 1 | 4 |
| **Qb9** | 21978 | 1.50 | 0.62 | 1 | 4 |
| **D1** | 21978 |  |  |  |  |
| *Left* | *1853* |  |  |  |  |
| *Centre-letf* | *3856* |  |  |  |  |
| *Centre* | *7968* |  |  |  |  |
| *Centre-right* | *3470* |  |  |  |  |
| *Right* | *1603* |  |  |  |  |
| *Not positionable* | *3228* |  |  |  |  |
| **D7** | 21978 |  |  |  |  |
| *Partner* | *7791* |  |  |  |  |
| *Patner and children* | *7000* |  |  |  |  |
| *Single* | *5975* |  |  |  |  |
| *Single with children* | *1120* |  |  |  |  |
| *Refusal/Other* | *92* |  |  |  |  |
| **D8** | 21978 |  |  |  |  |
| *Up to 15 years old* | *2665* |  |  |  |  |
| *16-19 years old* | *10013* |  |  |  |  |
| *20+ years old* | *8981* |  |  |  |  |
| *Refusal/dk* | *319* |  |  |  |  |
| **D10** | 21978 |  |  |  |  |
| *Man* | *10527* |  |  |  |  |
| *Woman* | *11451* |  |  |  |  |
| **D11** | 21978 | 50.51 | 17.88 | 15 | 98 |
| **D25** | 21978 |  |  |  |  |
| *Rural area or village* | *7068* |  |  |  |  |
| *Small or middle sized town* | *8510* |  |  |  |  |
| *Large town* | *6396* |  |  |  |  |
| *Dk* | *4* |  |  |  |  |
| **D63** | 21978 |  |  |  |  |
| *The higher class of society* | *154* |  |  |  |  |
| *The lower middle class of society* | *3456* |  |  |  |  |
| *The middle class of society* | *10942* |  |  |  |  |
| *The upper middle class of society* | *1630* |  |  |  |  |
| *The working class of society* | *5276* |  |  |  |  |
| *Refusal/Other* | *520* |  |  |  |  |

**APPENDIX C. Sample composition**

|  |  |
| --- | --- |
| **Country** | **Obs.** |
| Austria | 830 |
| Belgium | 970 |
| Bulgaria | 626 |
| Croatia | 904 |
| Cyprus | 411 |
| Czech Republic | 729 |
| Denmark | 839 |
| Estonia | 520 |
| Finland | 807 |
| France | 797 |
| Germany | 1200 |
| Greece | 854 |
| Hungary | 900 |
| Ireland | 928 |
| Italy | 905 |
| Latvia | 687 |
| Lithuania | 704 |
| Luxembourg | 399 |
| Malta | 397 |
| Netherlands | 883 |
| Poland | 710 |
| Portugal | 863 |
| Romania | 869 |
| Slovakia | 810 |
| Slovenia | 874 |
| Spain | 820 |
| Sweden | 890 |
| United Kingdom | 852 |
| **Total** | **21978** |

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1. See table 1 for the list of variables. [↑](#footnote-ref-1)
2. See Appendix A for the list of variables. [↑](#footnote-ref-2)
3. See Appendix B for the summary statistics. [↑](#footnote-ref-3)
4. See Appendix C for the number of observations according to country. [↑](#footnote-ref-4)